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Nitrates in Livestock Waters

**Cooperative Extension Service
South Dakota State University
U. S. Department of Agriculture**

Nitrates in Livestock Waters

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Sometimes, nitrates occur in our forages at levels high enough to make them toxic for livestock (see Fact Sheet 420). In addition, there has been concern about nitrates in waters and their possible effects on farm animals.

This Fact Sheet: (1) briefly reviews the sources of nitrates in waters, (2) discusses the way in which nitrates poison animals and the extent of the problem as it relates to livestock waters, (3) sets guidelines for the safe use for livestock of waters containing nitrates, and (4) clarifies some possible misunderstandings of the nature of the problem. The statements made here are based upon a critical and extensive review of the published experimental work and on years of observation of the nitrate problem at the South Dakota Agricultural Experiment Station.

Sources and Movement of Nitrates in Water

Possible sources of nitrates in waters include animal excreta, crop residues, human wastes, some industrial wastes, nitrogen fertilizers, and especially those nitrates occurring naturally in soils.

Nitrates are soluble and they move with water. Any added to or produced within the soil may be washed away by surface runoff or leached by ground water percolation. Ground water pumped from a well may contain nitrates even if the nitrogen source is a considerable distance from the well.

Waters from shallow wells normally contain more nitrates than those from deeper wells. Shallow wells containing nitrates are often improperly constructed and this may allow the direct entrance of polluted surface and subsurface water. They are often no deeper than the shallowest water-bearing strata or even the water table, and these are the ground water sources most easily polluted with leached nitrates. A deep well, on the other hand, does not assure nitrate-free water. An improperly located and constructed deep drilled well can also be polluted with surface or ground water. Pollutants can enter deep aquifers through abandoned wells that have not been properly sealed, through rusted and perforated well

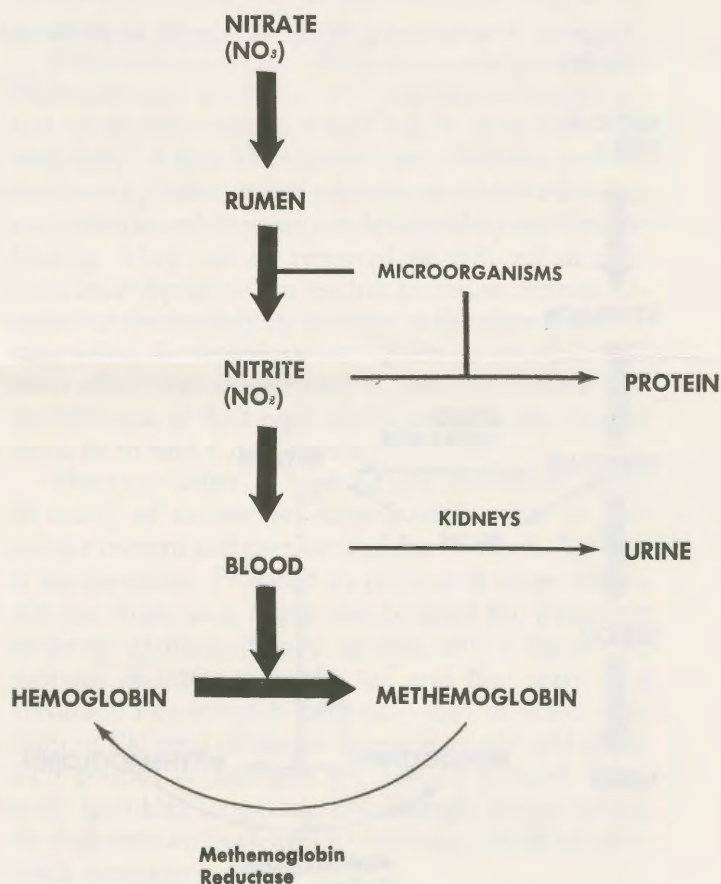
casings, and through old wells that have been carelessly used for sewage or waste disposal. However, the major part of the nitrates in South Dakota well waters is probably derived from that which occurs naturally in our soils.

Why Nitrates Poison

Cattle, Sheep

Nitrates in themselves are not very toxic. However, in the first stomach (rumen) of the cow or sheep, the microorganisms that are present change nitrates to nitrites, and these are quite toxic (see Figure 1). Nitrites may be further acted upon by the microorganisms, their nitrogen eventually being converted into protein. However, in cows or sheep that consume

Figure 1. A simplified pathway for nitrates in ruminants.



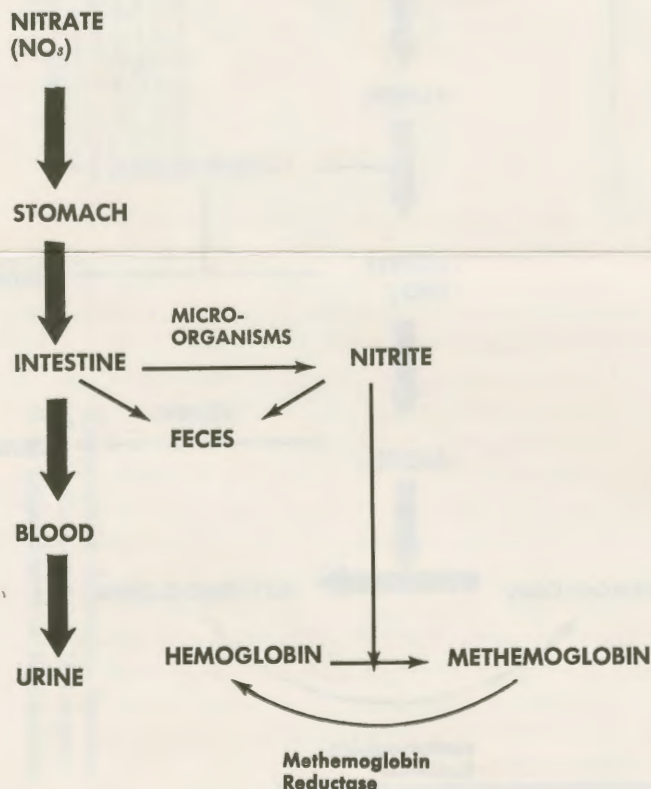
large amounts of nitrates all at one time, nitrites accumulate faster than they can be built into protein.

They will then be absorbed into the blood stream. While a small portion of the nitrites will be excreted in the urine, most will react with hemoglobin (the red, oxygen-carrying pigment of the blood) to form methemoglobin. This has a color different from that of hemoglobin, and when enough is formed the blood turns chocolate brown. Furthermore, it cannot carry oxygen, and if a large part of the hemoglobin has been converted to methemoglobin the animal shows symptoms of asphyxiation. These symptoms include labored breathing, a blue muzzle and a bluish tint to the whites of the eyes, trembling, inability to stand, and often death. Animals that recover will, except as in instances as noted below, show no after effects. Recovery is usually quite rapid, since there is present in the blood an enzyme (methemoglobin reductase) that converts methemoglobin back to hemoglobin. Exception to complete recovery concerns pregnant animals that have received so near a fatal dose that the fetus they carry dies and is later aborted.

Swine, Poultry

What happens in simple stomached animals such as swine and poultry? Here there is no fermentation vat similar to the rumen to aid in the digestion of roughages and to change nitrate to nitrite. In these cases, some nitrite may be formed in the intestinal

Figure 2. A simplified pathway for nitrates in swine and poultry.



tract (see Figure 2), but this is so small an amount that it is of no consequence to animal health. Most of the nitrate passes unchanged from the intestines into the blood and then out in the urine. While nitrate, itself, has some physiological effects, they are small when compared to those of nitrite, and it is doubtful that nitrate ever occurs naturally in waters at levels high enough to harm swine and poultry. Horses are simple stomached, but they have a large cecum (appendix), and this acts much like the rumen in digesting roughages. Nitrite formation can take place in this organ, and horses are susceptible to nitrate poisoning because of this.

In the human infant, cases of methemoglobinemia (blue babies) resulting from nitrate in water have been reported. It has been suggested that conditions in the digestive tract of the newborn favor the conversion of nitrate to nitrite and that the infant's methemoglobin reductase system may not be functional, making them more susceptible to nitrate poisoning than are adults. The situation has not been found to exist in livestock.

Dangerous Levels

How much nitrate must water contain to make it dangerous to livestock? A number of factors must be taken into account in arriving at such a value. These include the kind and age of animal, weather conditions that affect water intake, the kind of feed, and the nitrate content of the feed. Taking these into account and allowing for a reasonable margin of safety, the guide shown in Table 1 was developed. This guide is based upon the published results of research and it has been tested by years of observation at the South Dakota Agricultural Experiment Station. While others may have published recommendations suggesting that nitrate is toxic at much lower levels, there is no experimental justification for such recommendations. Actually, waters containing sufficient nitrate to cause livestock poisoning are very seldom found in South Dakota.

It should be pointed out that there are a number of ways in which chemists have reported the nitrate contents of waters, and this has lead to mistaken interpretations. Factors for converting other methods of reporting to a nitrate nitrogen basis are shown in the footnotes for Table 1.

It is important to stress here that the recommendations in Table 1 pertain to livestock and *not to man*.

Nitrites In Waters

Do we find nitrites in waters? Yes, but only at very low levels.

Rarely are they found at a concentration of over one or two parts per million of nitrite nitrogen, and this is far below what is needed to make water unfit for consumption by livestock and poultry. It is true

Table 1. A guide to the use for livestock of waters containing nitrates.

Nitrate content* as parts per million (ppm) of nitrate nitrogen (NO ₃ N)†	Comments
Less than 100	Experimental evidence indicates that this water should not harm livestock or poultry.
100 to 300	This water should not by itself harm livestock or poultry. If hays, forages or silages contain high levels of nitrate this water may contribute significantly to a nitrate problem in cattle, sheep, or horses.
Over 300	This water could cause typical nitrate poisoning in cattle, sheep, or horses, and its use for these animals is not recommended. Because this level of nitrate contributes to the salts content in a significant amount, the use of this water for swine or poultry should be avoided.

*The values shown include nitrate and nitrite nitrogen. In no case should the waters contain more than 50 ppm nitrite nitrogen (NO₂N) because of the greater toxicity of the nitrite form.

†1 ppm of nitrate nitrogen is equivalent to:

4.4 ppm of nitrate (NO₃)

6.1 ppm of sodium nitrate (NaNO₃)

7.2 ppm of potassium nitrate (KNO₃)

1 milliequivalent (meq) per liter of nitrate nitrogen is equivalent to 14 ppm.

that in dirty water troughs microorganisms might grow and bring about a change of nitrate to nitrite, but the extent of this change has been found to be small. It has also been suggested that the zinc in galvanized tanks or troughs catalyzes the change of nitrate to nitrite, but there are no experimental data to show that such a thing happens under farm conditions, and, further, there is no sound theoretical basis for assuming that this should happen. The recommendations in Table 1 provide for the accumulation of nitrite at levels of up to 50 ppm of nitrite nitrogen, and this is many times higher than what has been found under extreme experimental conditions involving highly contaminated, galvanized waterers. In short, nitrites in water supplies seem to offer no problems to livestock.

Chlorination

Does chlorination destroy nitrates in waters? No.

Why then has it been recommended by some as a remedy for high nitrate waters? Very simply, because of a misunderstanding of the nature of the nitrate problem.

The idea is based upon two truths: (1) that chlorine can convert nitrites back to nitrates, and (2) that

chlorine can kill microorganisms that might cause nitrate to be changed to nitrite.

But let's look at some additional facts:

It has already been pointed out that nitrites do not occur naturally at dangerous levels in waters. Thus, chlorination to change them back to nitrates is not necessary. Furthermore while chlorination will destroy microorganisms, the introduction of filth into water destroys the effectiveness of the chlorination, and if nitrites are to be formed from nitrates in water troughs it is essential that such filth be present to provide for the growth of the microorganisms. In addition, chlorine in the water cannot prevent the change of nitrate to nitrite in the rumen of the cow or sheep or in the cecum of the horse unless its level is such that it would cause physiological damage to the animal. Finally, and this is very important, there are no experimental data at all to show that chlorination at levels that could reasonably be recommended for use are effective against the poisoning of livestock by waters of high nitrate content. In brief, chlorination should not be considered as a remedy for high nitrate waters. If properly used, however, it can be effective in reducing pathogenic or iron bacteria and some odors.

Solving The Problem

If a water contains nitrates at a concentration that makes it unsuitable for use for livestock, what can be done about it?

Eliminating surface nitrate sources or preventing their entry into the water by improving well construction or by diverting polluted water away from the well may be helpful in some cases. Nitrates are not removed by filters, water softeners, or added softening compounds, and they are not destroyed by standing or boiling. They can be removed or reduced in concentration by some ion exchange resins, reverse osmosis, or electrodialysis, but costs make these practices impractical for treating livestock waters. In almost all cases where waters are found unsuitable for farm animals because of their high nitrate contents, the remedy must be to find a new source.

How can water of high nitrate content be used? It could, of course, be diluted with water of low nitrate content and then be used for livestock. But this is inconvenient. Provided its content of other salts is not too high, such water can be used for irrigating crops or gardens. It may, in fact, add a significant amount of nitrogen to the soil and thus serve as a fertilizer. For instance, each acre inch of water containing 100 ppm of nitrate nitrogen would add about 22.5 pounds of nitrogen per acre of ground. Even with sprinkler irrigation, not enough nitrate would be deposited on the leaves to cause a problem for livestock consuming them.

--- Sending Water Samples ---

Where can you find out about the nitrate content of your water supply? By sending a sample to:

Water Quality Laboratory
South Dakota State University
Brookings, S. Dak. 57006

The sample to be sent should consist of at least one pint of water. The sample should be representative so that the analysis will be meaningful, that is, wells should be pumped for a few minutes before sampling. Also be sure the sample is adequately packaged to prevent breakage en route. Your county Extension office has complete instructions and a schedule of the charges made for water analyses.

Nitrate levels may fluctuate rather widely following wet versus dry periods, so tests at different times of the year may be wise.

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